TITLE OF THE INVENTION

EXPOSURE DECIDING METHOD

5   FIELD OF THE INVENTION

        This invention relates to a technique for
deciding laser exposure when an image is formed by an
electrophotographic process.

10
                    BACKGROUND OF THE INVENTION

        An image forming apparatus that relies upon
electrophotography is used in printers and copiers and
15   finds wide use particularly in business applications.
Reproducibility and resolvability of character and
line images are strongly demanded in such business
applications.
        In general, image formation using an
20   electrophotographic process of the kind described
below is carried out in an image forming apparatus
that relies upon electrophotographic or electrostatic
printing.
        First, the surface of an image carrier such as an
25   electrophotographic photosensitive body or
electrostatic printing dielectric is charged
uniformly by a charging member. (This is a charging

step.)

Next, light corresponding to an image is shined upon an exposing station and electric charge in the portion exposed to the light is removed, thereby

5   forming an electrostatic latent image that corresponds to the image. (This as a latent-image forming step.)

The electrostatic latent image is developed and converted to a visible image at a developing station. (This is a toner developing step.)

10   This image is transferred to a transfer medium (transfer step) at a transfer station and is then fixed (fixing step).

Further, in order to control individually the amount of toner particles developed on each area of

15   the image-carrier surface, usually the amount of electric charge in each area is controlled, i.e., the amount of laser exposure of each area is controlled. In order to realize high density locally in an image, the sole method used is to enlarge the amount of laser

20   exposure of the particular area. Further, PWM (pulse-width modulation) or intensity modulation is used to control such laser exposure.

In general, the resolution of an image output device is not always as high as required. When

25   diagonal lines are output, therefore, jaggies may occur. Of course, since resolving power of image output is expressed in units of resolution, the

thickness of a line, for example, is increased or decreased in units of the resolution of the image output device. When a fine line, etc., is output, therefore, an output that has been rounded by the

5 resolution of the image output device may be produced rather than the original fine line. As a consequence, the output line may be thicker than the line intended to be output.

Anti-aliasing processing is well known as means

10 for solving this problem, namely how to obtain a smooth image output using a low-resolution image output device.

Anti-aliasing is a technique generally used in image output and usually is implemented using a

15 technique referred to as "over-sampling". Specifically, after print image data is expanded (over-sampled) at a resolution higher than the actual resolution of the image output device, the high-resolution image data is converted to data having a

20 resolution identical with the actual resolution of the image output device. As a result, the low-resolution image data obtained is output from the image output device.

For example, in case of image output from an

25 image output device having a resolution of 600 dpi, the output image data is expanded at twice the resolution, namely at 1200 dpi, then the data

undergoes a resolution conversion to 600 dpi and the
600-dpi image data is finally output from the image
output device.

In the event of such anti-aliasing, small values
5 equivalent to the color gray are provided as pixel
values for the pixels adjacent black diagonal lines
and small dots are thus formed at these adjacent
pixels where jaggies would have occurred originally.
This makes it possible to output smooth, jaggie-free
10 lines that also have a thickness identical with that
originally intended for output.

An actual example of the above will now be
described.

Fig. 1 is a diagram illustrating outline data of
15 the character "H". Fig. 2 is a diagram in which the
character "H" shown in Fig. 1 has been expanded at 600
dpi. Fig. 3 is a diagram illustrating an image
obtained by outputting the expanded data using an
electrophotographic apparatus having a resolution of
20 600 dpi.

As depicted in Fig. 2, the proportions of the
character are altered and the shape of the character
changes significantly when the image is expanded at
600 dpi. Line width of the character also becomes
25 greater than originally intended. This detracts from
printing quality, as illustrated in Fig. 3.

In order to prevent such a decline in image

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quality, anti-aliasing is applied. Specifically,
first the image is expanded using a resolution higher
than the output resolution. For example, expansion is
performed at a resolution of 1200 dpi, which is higher

5   than the 600-dpi resolution of the image output device,
as shown in Fig. 4. In this case there is little
degradation of the outline image data shown in Fig. 1.
Next, the data that has been expanded at 1200 dpi is
converted to half this resolution, namely to 600 dpi

10   (i.e., a resolution equal to the resolution of the
image output device). The resolution conversion
averages the 1200-dpi data in areas of, e.g., 2 × 2
using a 2 × 2 matrix of the kind shown in Fig. 5,
thereby achieving the conversion to 600-dpi data. In

15   the example shown in Fig. 5, each pixel of 1200-dpi
data is simply averaged in the 1200-dpi 2 × 2 area
(i.e., an area of one dot of 600 dpi) and the pixel
value of one dot of 600 dpi is calculated.

    For example, 1200-dpi data shown in Fig. 4 is

20   converted to 600-dpi data of the kind shown in Fig. 6.
As a result, a print image output from the image
output device is as illustrated in Fig. 7.
Specifically, it will be understood that the loss of
proportions and the change in line width that occur at

25   600 dpi are improved upon in the case of an output
using anti-aliasing. Fig. 8 is a diagram illustrating

a comparison between 600- and 1200-dpi printouts and a printout that is obtained upon effecting a resolution conversion to 600 dpi following expansion at 1200 dpi.

As shown in Fig. 9, anti-aliasing forms small-

5   size dots by outputting half-tones with respect to areas in which jaggies would occur conventionally. This therefore is a very effective method through which it becomes possible to manifest a large jaggies-suppression effect and achieve an output that is

10   faithful to the original image data.

When the conventional anti-aliasing processing described above is applied, however, the following problem arises:

Fig. 10 is a diagram illustrating a process

15   through which an outline font of the character "H" is expanded at 1200 dpi followed by a resolution conversion to 600 dpi and output of the resulting data. Further, Fig. 11 is a diagram illustrating a comparison between 1200-dpi expanded data and 600-dpi

20   output data. In the 1200-dpi expanded data of Fig. 11, the thicknesses of the two vertical lines in the character "H" are entirely the same, as illustrated at A and B. There is no difference at all between A and B. By contrast, in the 600-dpi output data, the two

25   vertical lines A' and B' in the character "H" are different.

This is caused depending upon whether or not the

line portions fall within the 2 × 2 matrix. Owing to
the difference in image formation that arises from the
difference in conditions at the time of the resolution
conversion, the two vertical lines do not necessarily

5   give the appearance of identical densities to the
observer (who is viewing the printed image) and the
image that should provide the same thicknesses
(densities) originally is output with different
thicknesses (densities) unintentionally.

10   The reason for this problem is as follows: With
image data in the stage where it has been over-sampled
at a high resolution, an area in which conditions are
the same is handled under different conditions in
resolution conversion processing when the area is

15   subjected to a resolution conversion and converted to
low resolution and, as a result, a conversion is made
to different image formation states. Thus, density
and shape of an output image is not uniform between
areas in which image formation states differ from one

20   another.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention

25   is to set appropriately amount of laser exposure based
upon an electrophotographic process, thereby
preventing non-uniformity of density and shape of an

image and performing stable, high-quality image output.

According to the present invention, the foregoing object is attained by providing an exposure deciding method for deciding laser exposure when image

5 formation is performed by an electrophotographic process, comprising: an expansion step of expanding image data at a resolution higher that actual resolution of an output apparatus; a resolution conversion step of subjecting high-resolution data,

10 which is the result of expansion at the expansion step, to a resolution conversion to the actual resolution of the output apparatus; an exposure decision step of deciding laser exposure when image formation is performed in such a manner that density of prescribed

15 image data will be the same before and after image formation; and an image formation step of forming an image represented by image data, which has undergone the resolution conversion performed at the resolution conversion step, based upon the laser exposure that

20 has been decided at the exposure decision step.

Further, according to the present invention, the foregoing object is attained by providing an image forming apparatus for deciding laser exposure when image formation is performed by an electrophotographic

25 process, comprising: expansion means for expanding image data at a resolution higher that actual resolution of an output apparatus; resolution

conversion means for subjecting high-resolution data,
which is the result of expansion by the expansion
means, to a resolution conversion to the actual
resolution of the output apparatus; exposure decision
5   means for deciding laser exposure when image formation
is performed in such a manner that density of
prescribed image data will be the same before and
after image formation; and image formation means
forming an image represented by image data, which has
10   undergone the resolution conversion performed by the
resolution conversion means, based upon the laser
exposure that has been decided by the exposure
decision means.

Other features and advantages of the present
15   invention will be apparent from the following
description taken in conjunction with the accompanying
drawings, in which like reference characters designate
the same or similar parts throughout the figures
thereof.

20

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram illustrating outline data
representing the character "H";
25   Fig. 2 is a diagram in which the character "H"
has been expanded at 600 dpi;

Fig. 3 is a diagram illustrating an image that has been output by an electrophotographic apparatus having an output resolution of 600 dpi;

Fig. 4 is a diagram in which the character "H" has been expanded at 1200 dpi;

Fig. 5 is a diagram in which 1200-dpi data has been converted to 600-dpi data using a 2 × 2 matrix;

Fig. 6 is a diagram in which the 1200-dpi data shown in Fig. 4 has been converted in terms of resolution to 600-dpi data;

Fig. 7 is a diagram illustrating a printed image obtained by printing the 600-dpi data shown in Fig. 6;

Fig. 8 is a diagram illustrating a comparison between 600- and 1200-dpi printouts and a printout that is obtained upon effecting a resolution conversion to 600 dpi following expansion at 1200 dpi;

Fig. 9 is a diagram illustrating a printout in which the occurrence of jaggies has been reduced;

Fig. 10 is a diagram illustrating a process through which an outline font of the character "H" is expanded at 1200 dpi followed by a resolution conversion to 600 dpi and output of the resulting data;

Fig. 11 is a diagram illustrating a comparison between 1200-dpi expanded data and 600-dpi output data;

Fig. 12 is a diagram illustrating the structure of an image forming apparatus according to an embodiment of the present invention;

Figs. 13 and 14 are diagrams illustrating seven
5   types of reference patterns and seven types of formed test patches according to a first embodiment of the invention;

Fig. 15 is a diagram illustrating the relationship between image data and laser exposure
10 (compensation) according to the first embodiment;

Fig. 16 is a diagram illustrating a matrix used in a resolution conversion according to a second embodiment of the invention;

Fig. 17 is a diagram illustrating an example of a
15 resolution conversion according to the second embodiment;

Figs. 18 and 19 are diagrams illustrating eight types of reference patterns and eight types of formed test patches according to a second embodiment of the
20 invention;

Fig. 20 is a diagram illustrating the relationship between image data and laser exposure (compensation) according to the second embodiment;

Fig. 21 is a diagram illustrating a matrix used
25 in a resolution conversion according to a third embodiment of the invention;

Fig. 22 is a diagram illustrating reference patterns and a formed test patch according to the third embodiment; and

Fig. 23 is a diagram illustrating an example of

5   the structure of an image output apparatus according to this embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

10   Preferred embodiments of the present invention will now be described in detail with reference to the drawings.

In the embodiments, an image output apparatus having an actual resolution of 600 dpi for image

15   formation first expands image data at a high resolution of 1200 dpi in an area such as a character or vector image, then converts the 1200-dpi data to 600-dpi data using a 2 × 2 matrix and subjects the 600-dpi data to various conversions (laser-exposure

20   correction, etc.) and outputs the resulting image.

Further, though the layout per se at the original 1200 dpi is the same, the resolution conversion conditions differ. Accordingly, test patches of reference patterns that will result in different image

25   formation states at 600 dpi are formed, the test patches are read at the surface of an intermediate transfer belt, and laser exposures are set in such a

manner that these output results will approach one another, as a result of which there is created a laser-exposure correction table used in areas in which a resolution conversion was employed. This is a

5 characterizing feature of the invention.

<Structure of apparatus>

Fig. 23 is a diagram illustrating the structure of an image output apparatus according to this embodiment. In the example shown in Fig. 23, a laser

10 printer is described as an example of the image output apparatus. However, the present invention is not limited to this arrangement and may also be applied to an electrophotographic copier or facsimile machine.

A host computer 2300 shown in Fig. 23 is a

15 personal computer or the like and specifies printing of a document or image created by a prescribed application. A laser printer 2310 forms images based upon print data, e.g. page description language (PDL) sent from the host computer 2300.

20 The printer 2300 includes a printer controller 2311 that processes the print data sent from the host computer 2300; a data processor and generator 2312 for performing a resolution conversion and setting of laser exposure, the details of which will be described

25 later; a laser driver 2313 for driving a semiconductor laser 2314 based upon the laser exposure that has been set by the data processor and generator 2312; and an

image forming unit 2315 for forming an image in accordance with the laser exposure from the semiconductor laser 2314.

The operation of the laser printer 2310 (referred to as an image forming apparatus in Fig. 12) of this embodiment will now be described in detail with reference to Fig. 12.

Fig. 12 is a diagram illustrating the structure of an image forming apparatus according to this embodiment. As shown in Fig. 12, the image forming apparatus is an electrophotographic image forming apparatus that draws a latent image on the surface of a charged drum 1201 by laser exposure, develops the latent image using toner in a developing unit 1202, transfers the toner image to an intermediate transfer belt 1203, transfers the toner image from the intermediate transfer belt 1203 to transfer paper 1204, thereby forming a printed image, and fixes the printed image in a fixing unit 1205.

<Image expansion>

PDL that has entered the image forming apparatus from a personal computer is expanded into raster data by an image rasterizing unit 1210. Expansion into the raster image is performed for every type of image and is handled separately according to whether an image is a character/vector image or photographic image, by way of example. Here a character/vector image is expanded

at a resolution of 1200 dpi to obtain 1200-dpi raster
data.

<Resolution conversion>

The image data of the character/vector portions
5   expanded at 1200 dpi is converted to a resolution of
600 dpi by averaging a 2 × 2 area using a 2 × 2 matrix
[(1/4, 1/4), (1/4, 1/4)], as shown in Fig. 5, in a
resolution converter 1211. The image data obtained by
the resolution conversion is stored in an image memory
10   1212, the amount of exposure is decided by a laser-
exposure correction table (LUT) 1213, pulse-width
modulation is applied by a PWM unit 1214, the
modulated data is input to a laser driver 1215, and a
laser emission unit 1216 causes lasers to emit light,
15   thereby rendering latent images on corresponding
photosensitive drums 1201 and forming print images.

[First Embodiment]

Described next will be a method of setting laser
exposure in a first embodiment in which the image
20   forming apparatus of Fig. 12 forms test patches of
reference patterns during a phase of operation in
which an image is not being formed (this shall be
referred to as "non-image formation" below), reads the
test patches and creates the laser-exposure correction
25   table based upon the densities of the test patches
read.

<Reference image formation, reading of reference

image and correction of exposure>

First, during the non-image formation phase, seven types of test patches a', b', c', d', e', f', g' and h shown in Figs. 13 and 14 are formed. It should

5   be noted that reference characters a to h shown in Figs. 13 and 14 denote the corresponding reference patterns, in which h represents the reference pattern of a solid image.

The densities of a test patches that have been

10   formed on the intermediate transfer belt 1203 are measured by a density sensor 1206.

The test patches a', b', c' and d' shown in Fig. 14 are the result of applying a resolution conversion to the 1200-dpi line-image data a, b, c, and d,

15   respectively. The reference patterns a and b are originally identical patterns (only the positions differ). Similarly, the reference patterns c and d are originally identical patterns in which only positions differ.

20   Despite the fact that the patches a' and 'b or c' and d' basically are the same patterns at the time of the expansion at 1200 dpi, they become quite different in the exposure patterns after being subjected to an averaging and reducing process using a 2 × 2 matrix at

25   the time of the resolution conversion to 600 dpi.

Further, the patches e', f' and g' similarly are the result of applying a resolution conversion to

1200-dpi dot image data e, f, g. Here the patterns e, f and g are originally the same dot patterns. However, the image data obtained after the resolution conversion to 600 dpi differs greatly depending upon

5   how the 2 × 2 matrix used to perform averaging at the time of the resolution conversion to 600 dpi is deployed.

Usually, in a case where latent images having different exposure patterns are rendered in

10   electrophotography, the print image densities thereof will differ. In other words, a problem which arises is that despite the fact that line or character images should originally be the same at expansion at 1200 dpi, they become different lines or characters in the

15   printed image that is output after a resolution conversion to 600 dpi.

For example, if one considers a pattern in which a line having the same thickness is rendered repeatedly, the thickness of every other line changes

20   despite the fact that the lines are output at the same thickness. Regardless of the anti-aliasing processing (over-sampling) the original purpose of which is to raise the quality of line and character images, this purpose cannot be attained satisfactorily if the

25   above-described problem arises.

In order to solve the above problem, a laser exposure setting unit 1217 in the first embodiment

reads and measures the densities of the seven types of
test patches a', b', c', d', e', f', g' and h, which
have been formed during non-image formation, on the
intermediate transfer belt 1203 by the density sensor

5   1206, applies a laser exposure correction, creates the
laser-exposure correction table in such a manner that
the densities of a' and b' or of c' and d' become the
same and stores this table in the LUT 1213.

More specifically, a laser-exposure correction

10   table of the kind shown in Fig. 15 is created through
the procedure described below. Here the image data is
handled as data having 256 levels of 0 to 255.

(1) The test patch h on the intermediate
transfer belt 1203 is measured by the density sensor

15   1206 and a laser exposure corresponding to image data
255 that provides the highest density is set to an
exposure that will enable the image pattern h to
realize a reference solid density.

(2) The densities of patches c' and d' and of

20   the patches e' and g' formed on the intermediate
transfer belt 1203 are compared and the laser exposure
is decided in such a manner that both densities will
become the same. Here the test patch c' comprises
only image data 0 (it is assumed that the laser

25   exposure with regard to image data 0 has been decided
separately) and 255, and the laser exposure has
already been decided in the step above. Conversely,

the test patch d' is formed only from image data 128.
By comparing c' and d', therefore, it is possible to
uniquely decide a laser exposure that corresponds to
the image data 128.

5   Further, the test patch e' also comprises only
image data 0 and 255 and the laser exposure has
already been decided in the step above. Conversely,
the test patch g' is formed only from image data 128
and 0. By comparing e' and g', therefore, it is

10   possible to uniquely decide a laser exposure that
corresponds to the image data 128.

It should be noted that in a case where the laser
exposure corresponding to image data 128 obtained from
the test patches c', d' and from e', g' differs, then

15   the exposure is set to an intermediate value.

(3) The densities of patches e' and f' formed on
the intermediate transfer belt 1203 are compared and
the laser exposure corresponding to image data 64 is
decided in such a manner that both densities will

20   become the same. Here also the laser exposure with
respect to image data 0, 255 corresponding to test
patch e' has already been decided in a manner similar
to that of the step above. Since the test patch f' is
a pattern comprising image data 64 and 0, it is

25   possible to uniquely decide a laser exposure
corresponding to image data 64.

(4) The test patches a' and b' formed on the

intermediate transfer belt 1203 are compared and a laser exposure corresponding to image data 192 is decided in such a manner that both densities will be the same. Here also laser exposure with respect to

5   image data 0, 64, 255 corresponding to test patch b' has already been decided in a manner similar to that of the step above. Since the test patch a' is a pattern comprising image data 0 and 192, it is possible to uniquely decide a laser exposure

10 corresponding to image data 192.

(5) Laser exposures corresponding to image data 0, 64, 128, 192, 255 are decided up to the foregoing step. In a case where it is necessary to decide laser exposures corresponding to image date other than these

15 items of image data, these are set upon performing suitable interpolation and approximation, etc., based upon these values.

What becomes important in resolution is binary data (tone is not important, unlike the case of a

20 grayscale image). When a resolution conversion is performed from 1200-dpi binary data to 600-dpi multivalued data using a 2 × 2 resolution conversion matrix, only 0, 64, 128, 192, 255 among the data 0 to 255 are used. That is, the first embodiment sets all

25 multivalued outputs that appear in a case where resolution is converted from 1200-dpi binary data to 600-dpi multivalued data.

By setting an appropriate laser exposure through this process, it is possible to solve the above-described problem, namely that in a case where anti-aliasing processing using over-sampling is executed in

5   an electrophotographic apparatus, a conversion is made to different image formation states after image patterns that are originally the same are subjected to a resolution conversion and, as a result, different image densities are output.

10   In accordance with the first embodiment, as described above, test patches of reference patterns are formed during non-image formation and the test patches are read on an intermediate transfer belt, thereby creating a laser-exposure correction table

15   used in an area in which a resolution conversion was employed. In a case where anti-aliasing using over-sampling is executed by setting an appropriate exposure, it is possible to prevent a situation in which image patterns that are originally the same are

20   converted to different image formation states after the resolution conversion, as a result of which the patterns are output at different image densities.

Further, according to the first embodiment, the laser-exposure correction table is created on the

25   assumption that the coefficients of the matrix used in resolution conversion are fixed. However, this does not impose a limitation upon the invention and similar

effects can be obtained by changing (e.g., increasing or decreasing) the coefficients of the resolution conversion matrix based upon the output results.

[Second Embodiment]

5   A second embodiment of the present invention will now be described in detail with reference to the drawings.

The structure of the apparatus in the second embodiment is similar to that shown in Fig. 12 used in

10   the first embodiment and need not be described again. The second embodiment is characterized in that the matrix used in the resolution conversion differs from that of the first embodiment. Specifically, use is made of a matrix in which 600-dpi boxes are shifted by

15   one-half pixel with respect to 1200-dpi boxes, as illustrated in Fig. 16.

<Resolution conversion>

In the second embodiment, the image data of character/vector portions expanded at 1200 dpi is

20   converted to a resolution of 600 dpi by averaging using a matrix of the kind shown in Fig. 16 in the resolution converter 1211 in a manner similar to that of the first embodiment. Unlike the first embodiment, however, a resolution conversion is performed by

25   executing averaging processing using a matrix in which 600-dpi boxes are shifted by one-half pixel with respect to 1200-dpi boxes. As a result, a slight

difference occurs in line and character quality after
the resolution conversion.

Fig. 17 is a diagram illustrating an example of
resolution conversion according to the second

5   embodiment. Fig. 17 shows a result 1' obtained by
subjecting a 1200-dpi 1-dot diagonal line to a
resolution conversion according to the first
embodiment, and a result 2' obtained by subjecting a
1200-dpi, 1-dot diagonal line to a resolution

10   conversion according to the second embodiment. With
the resolution conversion according to the first
embodiment, four 1200-dpi pixels are included in a 2 ×
2 matrix. Since there is no difference among the four
pixels, information relating to a difference in the

15   four pixels is lost after the resolution conversion.
Conversely, when an attempt is made to output a
pattern that fits within the 2 × 2 matrix, a 1200-dpi
position resolution is not obtained. As a consequence,
there are cases where the jaggies-suppression effect

20   is not obtained, as at the portion indicated by the
arrow in 1'.

By contrast, a resolution conversion according to
the second embodiment is such that if a pattern is
larger than a 1200-dpi, 1-dot pattern, resolution is

25   always converted in a state in which the pattern spans
a plurality of matrices. In other words, resolution
is converted while maintaining the 1200-dpi position

resolution as is. As a result, the jaggie-suppression effect will not be lost, as indicated at 2' in Fig. 17, even in the case of the aforementioned example, namely the 1200-dpi, 1-dot diagonal line.

5   <Reference image formation, reading of reference
         image and correction of exposure>

In a manner similar to that of the first embodiment, eight types of test patches i', j', k', l', m', n', o' and h shown in Figs. 18 and 19 are formed.

10   The densities of a test patches that have been formed on the intermediate transfer belt 1203 are measured by the density sensor 1206.

More specifically, a laser-exposure correction table of the kind shown in Fig. 20 is created through

15   the procedure described below. Here the image data is handled as data having 256 levels of 0 to 255.

(1) The test patch h on the intermediate transfer belt 1203 is measured by the density sensor 1206 and a laser exposure corresponding to image data

20   255 that provides the highest density is set to an exposure that will enable the image pattern h to realize a reference solid density.

(2) A laser exposure corresponding to image data 64 [= 255 × (4/16)] is decided in such a manner that

25   test patch i' formed on the intermediate transfer belt 1203 will distinctly become a dot image.

(3) The densities of patches i' and k' formed on

the intermediate transfer belt 1203 are compared and
the laser exposure for image data 32 [= 255 × (2/16)]
is decided in such a manner that both densities will
become the same. It should be noted that since the
test patch i' has already been decided in the step
above, it is possible to uniquely decide a laser
exposure that corresponds to the image data 32.

(4) The densities of patches i' and j' formed on
the intermediate transfer belt 1203 are compared and a
laser exposure corresponding to image data 16 [= 255 ×
(1/16)] is decided in such a manner that both
densities will become the same.

(5) The densities of patches l' and m' formed on
the intermediate transfer belt 1203 are compared and a
laser exposure corresponding to image data 128 [= 255 ×
(8/16)] is decided in such a manner that both
densities will become the same.

(6) The densities of patches n' and o' formed on
the intermediate transfer belt 1203 are compared and a
laser exposure corresponding to image data 192 [= 255 ×
(12/16)] is decided in such a manner that both
densities will become the same.

(7) Laser exposures corresponding to image data
0, 16, 32, 64, 128, 192, 255 are decided up to the
foregoing step. In a case where it is necessary to
decide laser exposures corresponding to image date

- 25 -

other than these items of image data, these are set upon performing suitable interpolation and approximation, etc., based upon these values.

By setting an appropriate laser exposure through this process according to the second embodiment, it is possible to solve the above-described problem, namely that in a case where anti-aliasing processing using over-sampling is executed in an electrophotographic apparatus, a conversion is made to different image formation states after image patterns that are originally the same are subjected to a resolution conversion and, as a result, different image densities are output. At the same time, owing to the fact that 1200-dpi boxes and 600-dpi boxes, which are the result of a resolution conversion, have been shifted by a half pixel of 1200-dpi pixels, it is possible to perform a resolution conversion while maintaining the 1200-dpi position resolution as is. In addition, a more stable, high-quality output can be obtained.

Further, according to the second embodiment, as in the first embodiment, the laser-exposure correction table is created on the assumption that the coefficients of the matrix used in resolution conversion are fixed. However, this does not impose a limitation upon the invention and similar effects can be obtained by changing (e.g., increasing or decreasing) the coefficients of the resolution

conversion matrix based upon the output results.

[Third Embodiment]

A third embodiment of the present invention will
now be described in detail with reference to the

5   drawings.

The structure of the apparatus in the third
embodiment is similar to that shown in Fig. 12 used in
the first and second embodiments and need not be
described again. The third embodiment is

10   characterized in that the matrix used in the
resolution conversion differs from those of the first
and second embodiments. Specifically, use is made of
a 4 × 4 matrix with respect to 1200 dpi, as shown in
Fig. 21. A further characteristic of the third

15   embodiment is that a plurality of test patterns are
output and the amount of laser exposure is set by
measuring position rather than density at the time of
measurement.

<Resolution conversion>

20   Fig. 21 is a diagram illustrating a matrix used
in a resolution conversion according to the third
embodiment. The matrix used in the third embodiment
is a 4 × 4 matrix. If a matrix with regard to all 600-
dpi pixels were to be displayed, identification in the

25   drawing would be difficult. Accordingly, here only
one matrix is displayed among four pixels of 600 dpi.

According to the third embodiment, averaging

processing is executed by a 4 × 4 matrix of the kind

shown in Fig. 21 when a resolution conversion is made

from 1200 dpi to 600 dpi. Therefore, each dot of 1200

dpi is decomposed always under identical conditions

5   into four peripheral points always at 600 dpi and the

image formation states are forced to be equal at any

of the points. What is different is only the

intensity balance among the four points. When a

comparison is made with the matrices used in the first

10   and second embodiments, therefore, it is possible to

perform an output of image patterns under

comparatively similar conditions in various patterns.

However, since the dots of 1200 dpi are

distributed while the four peripheral dots are

15   weighted, the position of the center of gravity of the

dots output changes depending upon the intensity of

weighting. For example, in case of a 1-dot, 6-space

line pattern at 1200 dpi shown in Fig. 22, it will be

understood that weighting balance in the horizontal

20   direction changes every other line. If such a pattern

is output, a problem which arises is that line spacing

changes every other line unless an appropriate

exposure correction is applied. In the case of the

example shown in Fig. 22, a difference in length

25   develops between line-to-line spacing A and line-to-

line spacing B.

In order to solve this problem, the third

embodiment is characterized in that test patches of

reference patterns are formed during non-image

formation, and a laser-exposure correction table is

created in such a manner that the centroid balance of

5   the output image will not be lost.

<Reference image formation, reading of reference

image and correction of exposure>

In the third embodiment, a pattern A in which an

A portion is repeated at fixed intervals from a

10   pattern p' shown in Fig. 22 and a portion B in which a

B portion is repeated at fixed intervals are formed

during non-image formation. In electrophotography,

density rises in a case where the spacing between two

lines diminishes. If the line spacing differs between

15   the patterns A and B, therefore, this is detected as a

difference in average densities between the patterns A

and B. Accordingly, if it is so arranged that a

difference in average densities will not occur between

the patterns A and B, then the line spacing between

20   the patterns A and B also will become equal.

Hence, according to the third embodiment, average

densities between patterns A, B formed on the

intermediate transfer belt 1203 are detected and the

laser-exposure ratio with respect to image data 106 [=

25   $255 \times (2+3+3+2)/24$] and image data 106 [= $255 \times$

$(1+2+2+1)/24$] is set in such a manner that the two

average densities will become the same.

Thus, the third embodiment solves the problem of the shift in output positions of lines or the like in an output image in a case where the anti-aliasing technique is used in electrophotography. Specifically,

5   by outputting test patterns and setting an appropriate laser-exposure ratio, the centroid balance of the output image is prevented from being shifted non-uniformly and it is possible to produce a stable, high-quality output.

10   According to the third embodiment, as in the first and second embodiments, the laser-exposure correction table is created on the assumption that the coefficients of the matrix used in resolution conversion are fixed. However, this does not impose a

15   limitation upon the invention and similar effects can be obtained by changing (e.g., increasing or decreasing) the coefficients of the resolution conversion matrix based upon the output results.

Further, the third embodiment is an alternative

20   to measuring the line distance between patterns A and B based upon measurement of average densities between patterns A and B. However, this does not impose a limitation upon the invention and equivalent effects can of course be obtained by directly measuring output

25   positions of lines and dots, etc.

As described above, in an electrophotographic apparatus for implementing anti-aliasing processing

using over-sampling, patterns that take on different image formation states after a resolution conversion despite the fact that the image patterns are originally the same at the time of high-resolution

5   development are formed as test patterns during non-image formation and the test patterns are measured, and a laser-exposure correction table used in an area in which a resolution conversion has been employed or a parameter used in a resolution conversion is decided

10   so as to make identical the patterns that take on different image formation states after a resolution conversion despite the fact that the image patterns are originally the same at the time of high-resolution development. As a result, in a case where anti-

15   aliasing processing used in over-sampling has been executed, it is possible to prevent, by appropriate control of exposure, a situation in which image patterns that are originally identical are converted to a different image formation state after a

20   resolution conversion and, as a consequence, different image densities are output.

The present invention can be applied to a system constituted by a plurality of devices (e.g., a host computer, interface, reader, printer, etc.) or to an

25   apparatus comprising a single device (e.g., a copier or facsimile machine, etc.).

Furthermore, it goes without saying that the

object of the invention is attained also by supplying

a recording medium storing the program codes of the

software for performing the functions of the foregoing

embodiments to a system or an apparatus, reading the

5   program codes with a computer (e.g., a CPU or MPU) of

the system or apparatus from the recording medium, and

then executing the program codes.

In this case, the program codes read from the

recording medium implement the novel functions of the

10   embodiments and the recording medium storing the

program codes constitutes the invention.

Examples of storage media that can be used for

supplying the program code are a floppy disk

(registered trademark), hard disk, optical disk,

15   magneto-optical disk, CD-ROM, CD-R, magnetic tape,

non-volatile type memory card or ROM, etc.

Furthermore, besides the case where the aforesaid

functions according to the embodiments are implemented

by executing the program codes read by a computer, it

20   goes without saying that the present invention covers

a case where an operating system or the like running

on the computer performs a part of or the entire

process in accordance with the designation of program

codes and implements the functions according to the

25   embodiments.

It goes without saying that the present invention

further covers a case where, after the program codes

read from the recording medium are written in a

function expansion board inserted into the computer or

in a memory provided in a function expansion unit

connected to the computer, a CPU or the like contained

5   in the function expansion board or function expansion

unit performs a part of or the entire process in

accordance with the designation of program codes and

implements the function of the above embodiments.

Thus, in accordance with the embodiment of the

10   invention as described above, amount of laser exposure

based upon an electrophotographic process is set

appropriately, thereby preventing non-uniformity of

density and shape of an image and performing stable,

high-quality image output.

15   As many apparently widely different embodiments

of the present invention can be made without departing

from the spirit and scope thereof, it is to be

understood that the invention is not limited to the

specific embodiments thereof except as defined in the

20   appended claims.